Development of radiative assessment for EarthCARE: 1D and 3D radiative transfer

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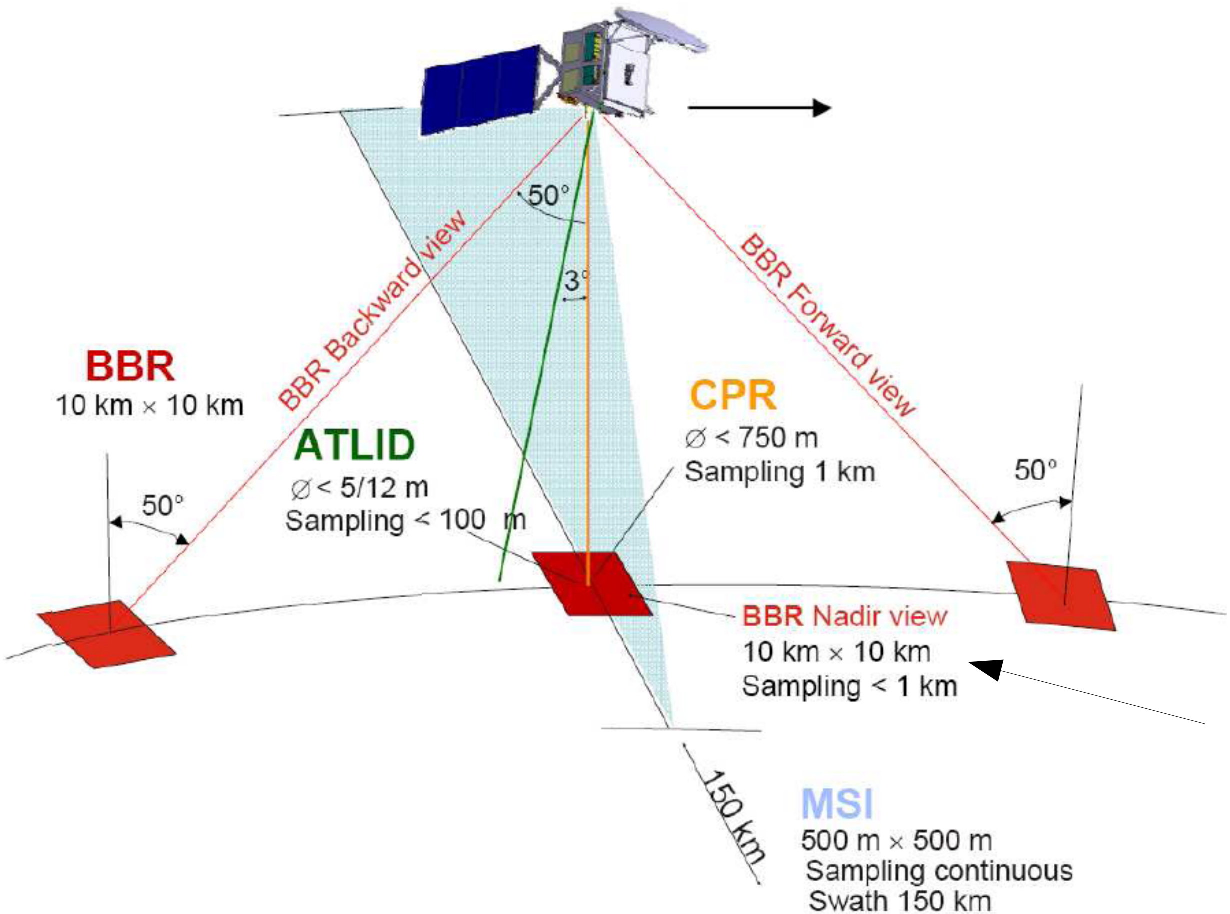
Outline

- What is EarthCARE?
- Where does 1D and 3D radiative transfer fit in to algorithms?
- Overview of SRC
  - Scene construction algorithm
  - Radiative transfer
  - Closure (radiative assessment)

EarthCARE-Earth Cloud and Radiation Explorer



Launch 2016ish

Footprint under discussion. Could be as small as 1 km x1 km.

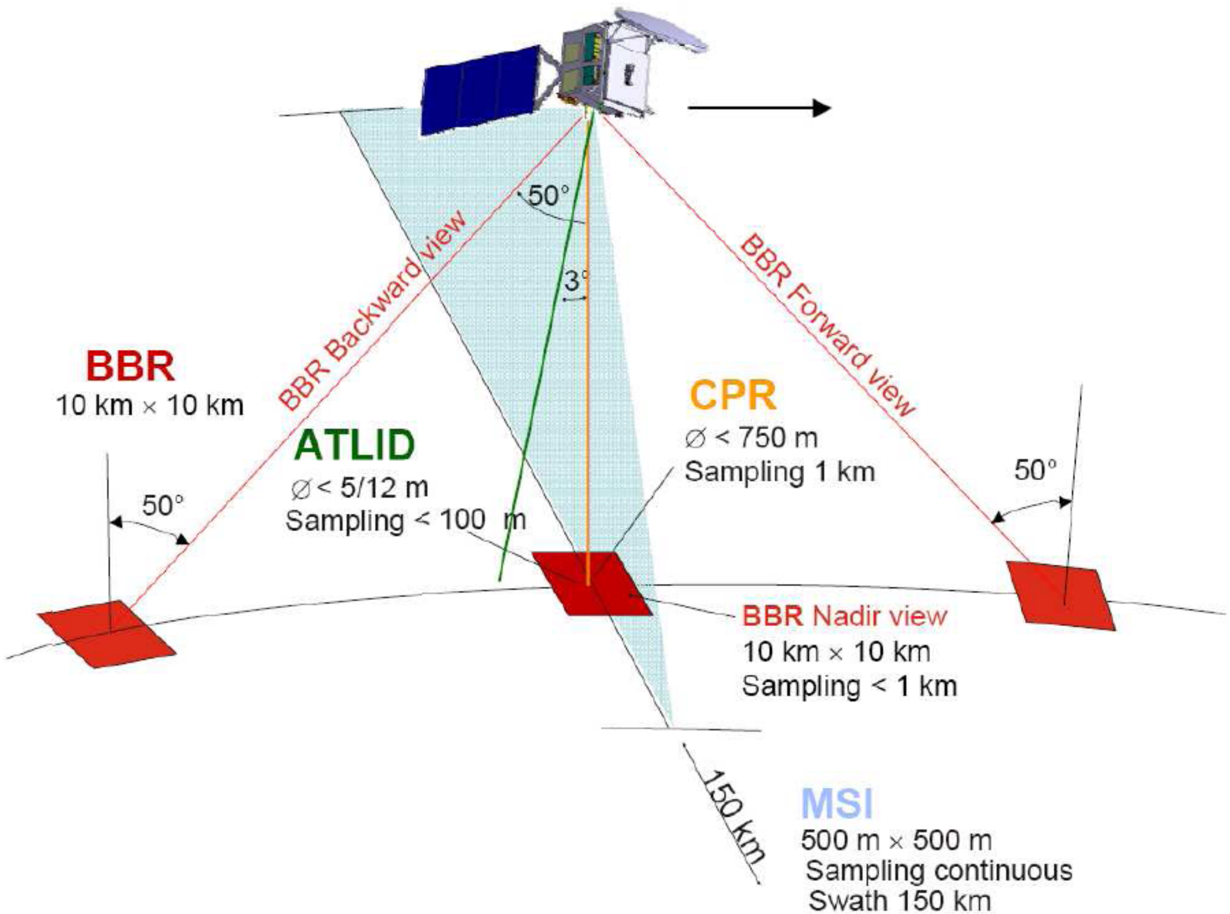
ATLID – 353 nm high spectral resolution lidar

CPR - W-band radar with Doppler capability

MSI – Multispectral imager

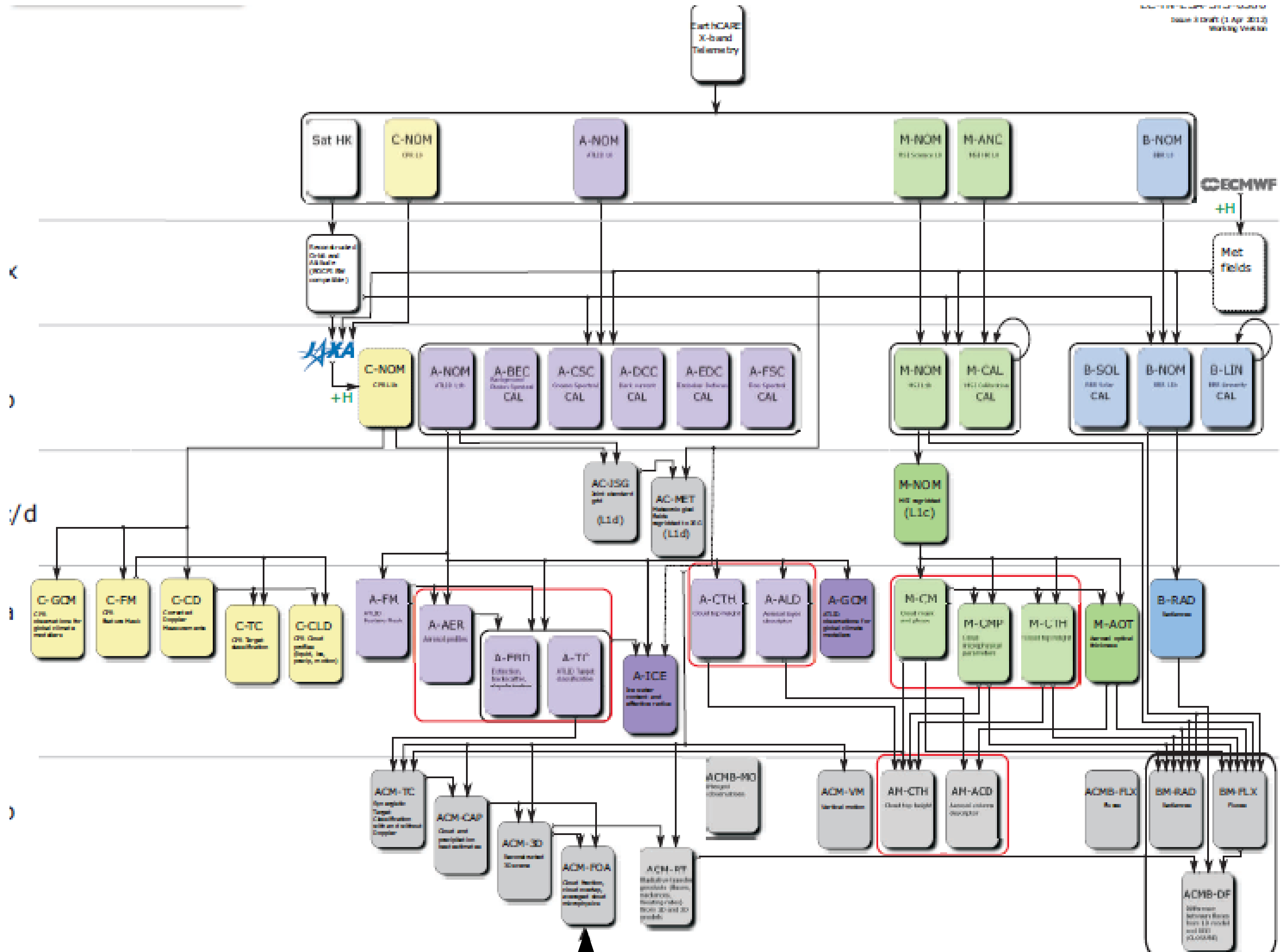
BBR – Solar and thermal broadband radiometer (3 views)

EarthCARE-Earth Cloud and Radiation Explorer



The accuracy placed upon the retrieved geophysical data products (cloud and aerosol profiles) is that which is consistent with a TOA flux accuracy of 10 W m−2 for an instantaneous footprint of 10x10 km.

Where does 1D and 3D radiative transfer fit in?

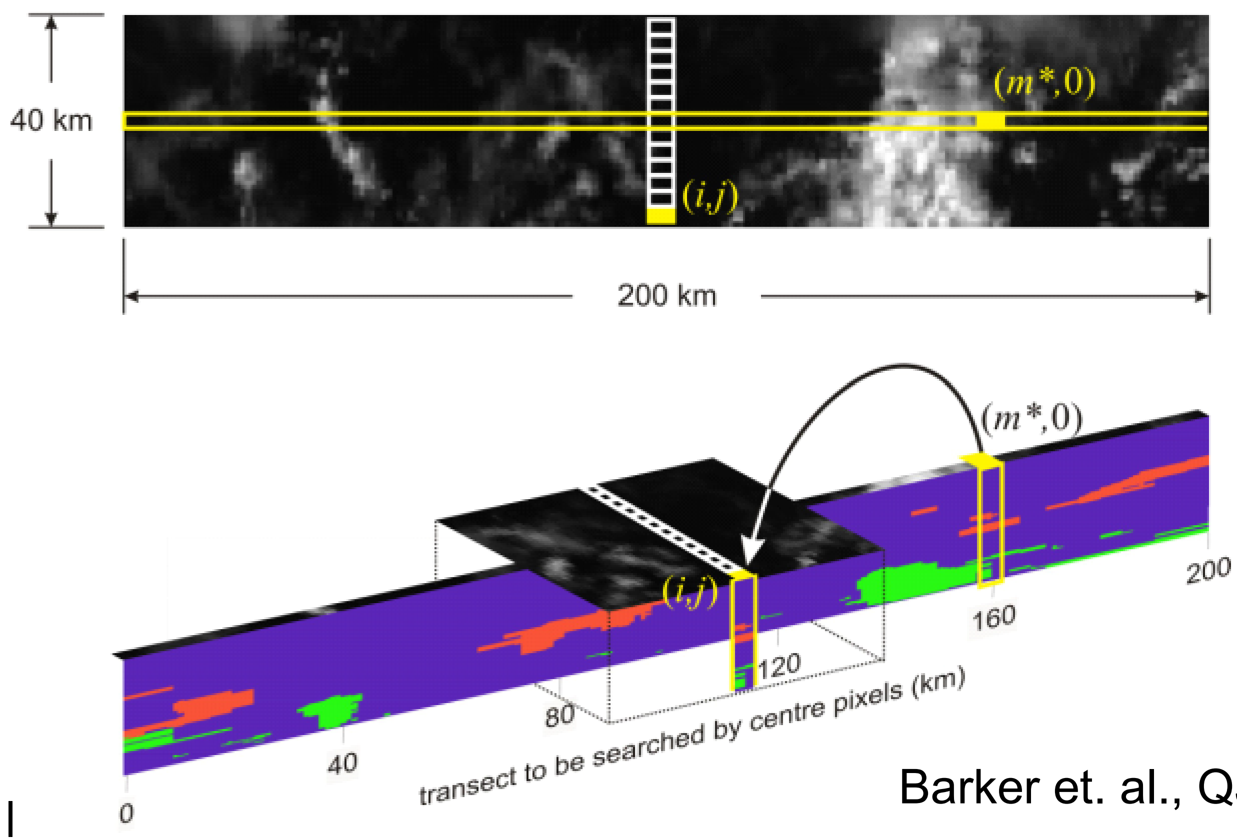


This is our RT box

SRC - Scene Construction

- Need to construct across track scene for 3D codes
- Use MODIS radiances to link off-line to on-line profiles
- Minimize cost function
- How to handle missing or bad data

Schematic of construction algorithm



Barker et. al., QJRMS, 2011

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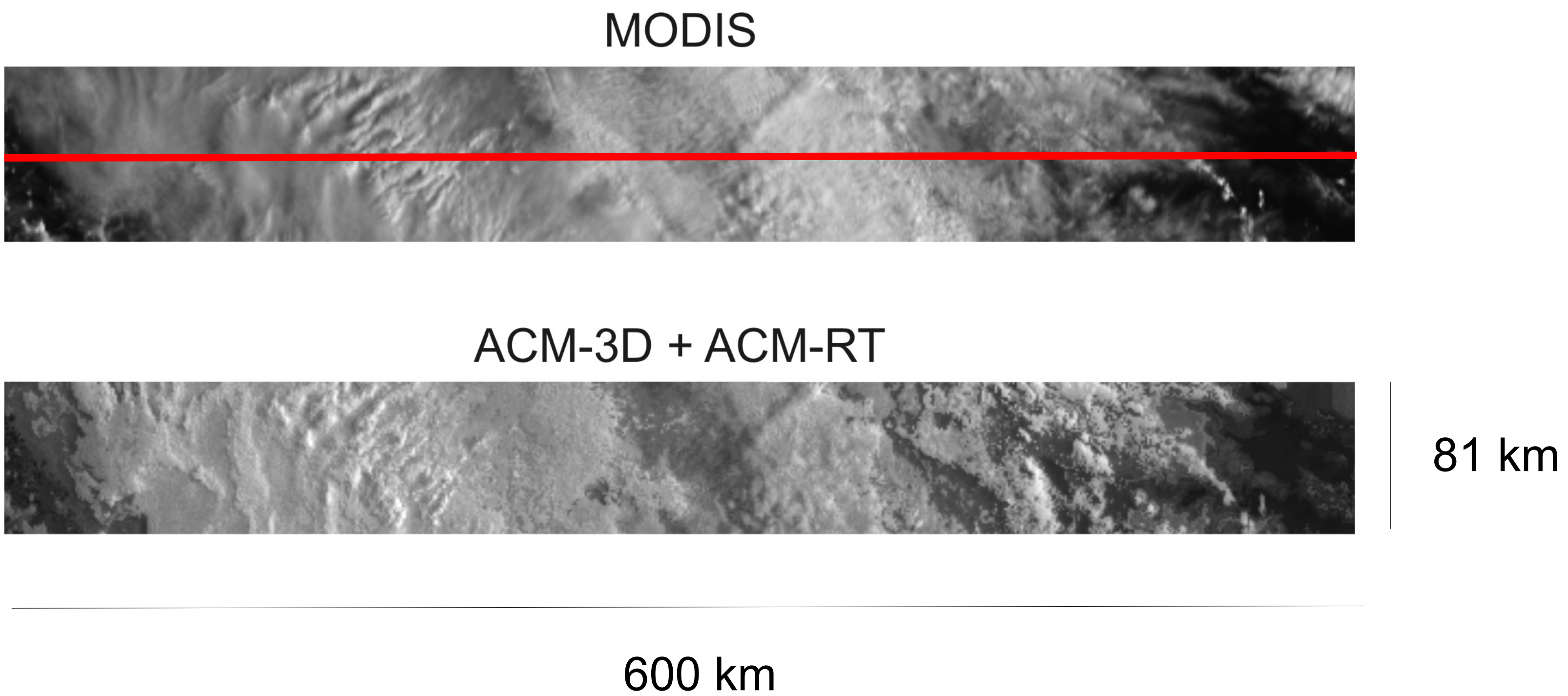
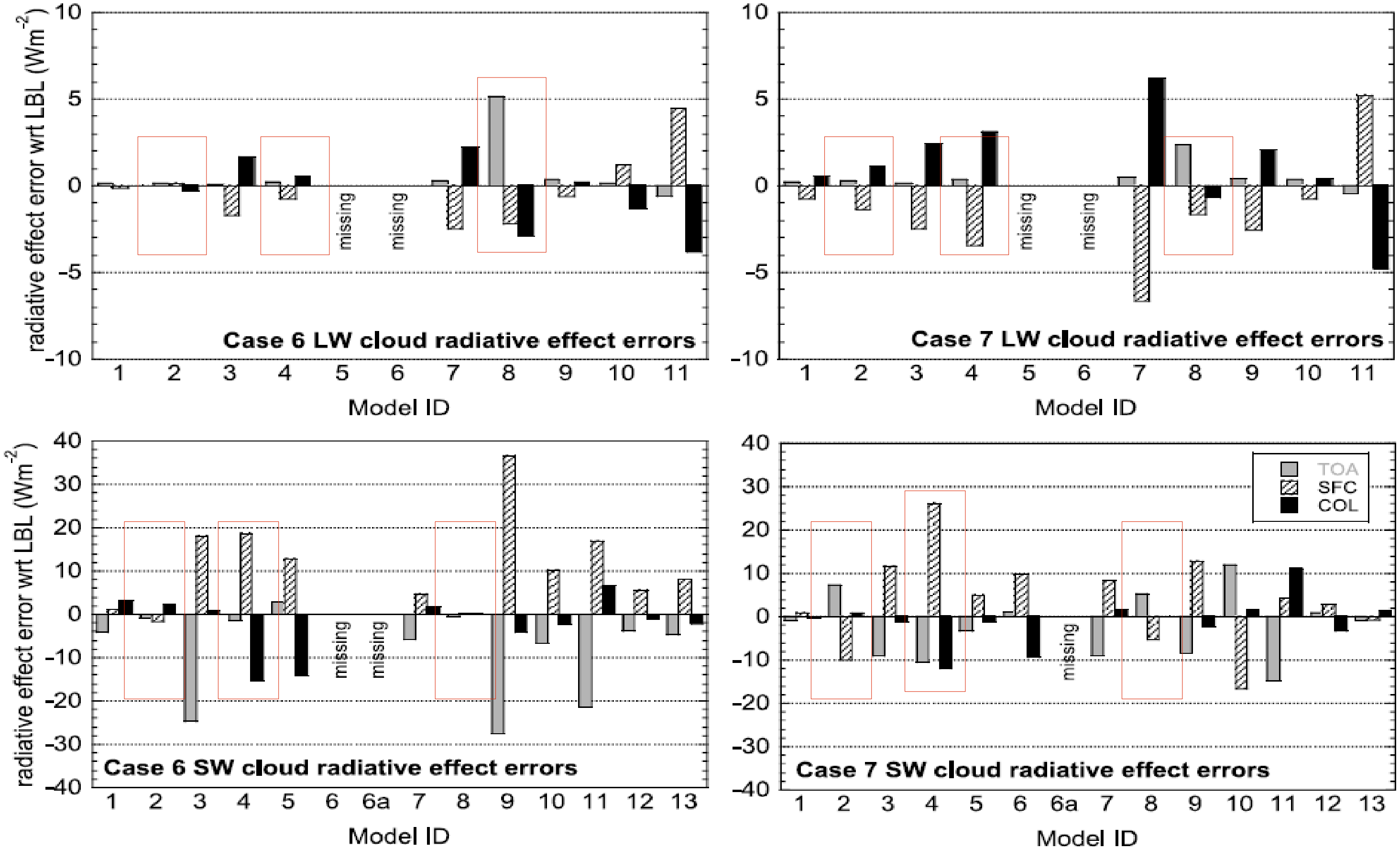


SRC - Radiative Transfer (1D)

Compute the radiative transfer using three 1D models

- RRTMG (used in NWP and GCMs)
- CCCma (from Canadian GCM)
- CERES Fu-Liou (continue CERES calculations) (to be added)

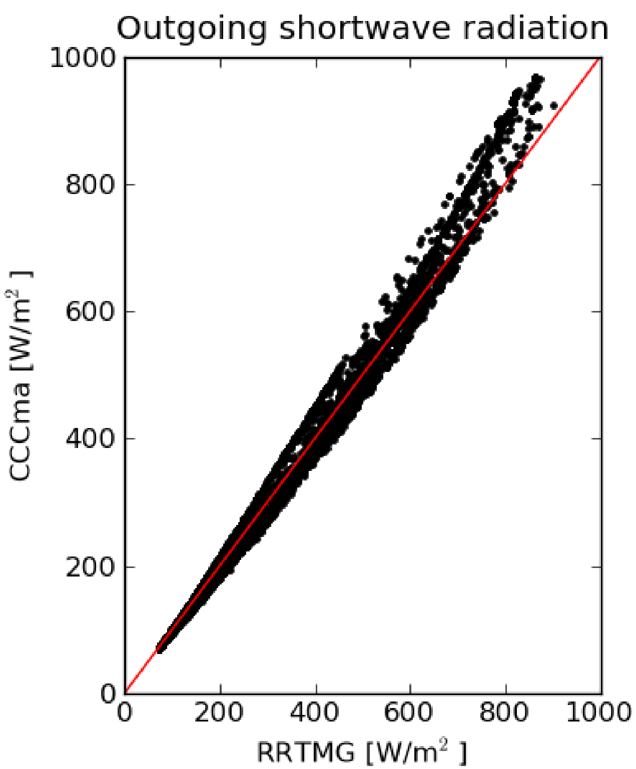


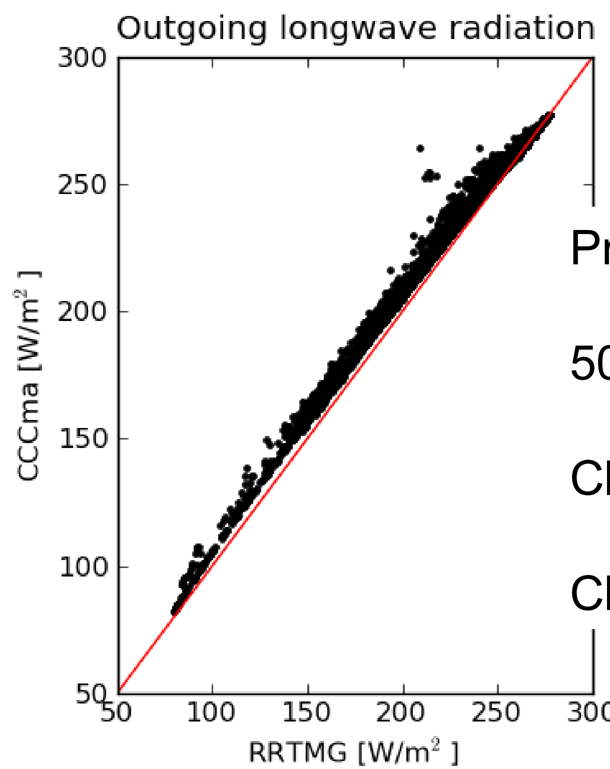
CIRC,Oreopoulos et. al., 2012

Liquid clouds only

SRC - Radiative Transfer (1D)

- To extent possible each code untouched
    - Each model uses its own optical properties for gas and Rayleigh
    - Surface albedo supplied from observations
    - liquid cloud properties from Mie calculations (TBD)
        - allow variations in variance and effective radius
    - ice optical properties from Yang (TBD)
- RRTMG optical properties are output and used by 3D codes





Preliminary results

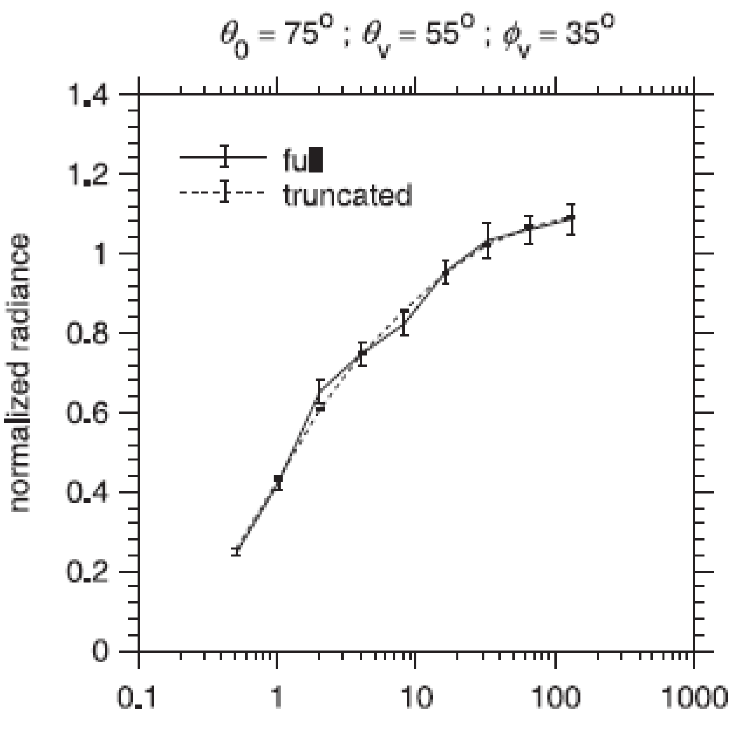
5000 km A-train data

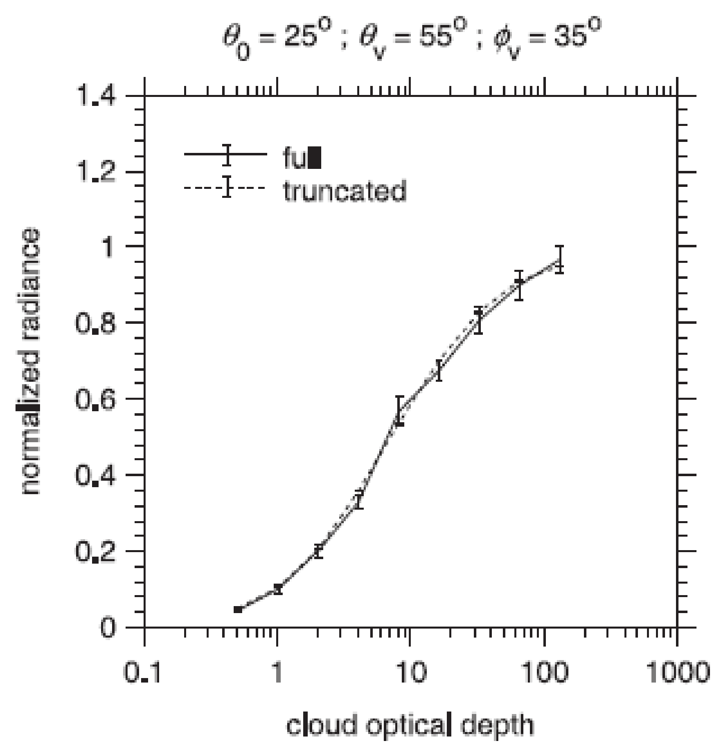
Clear-sky within 5 W/m^2

Cloudy sky a challenge

SRC - Radiative Transfer (3D Solar)

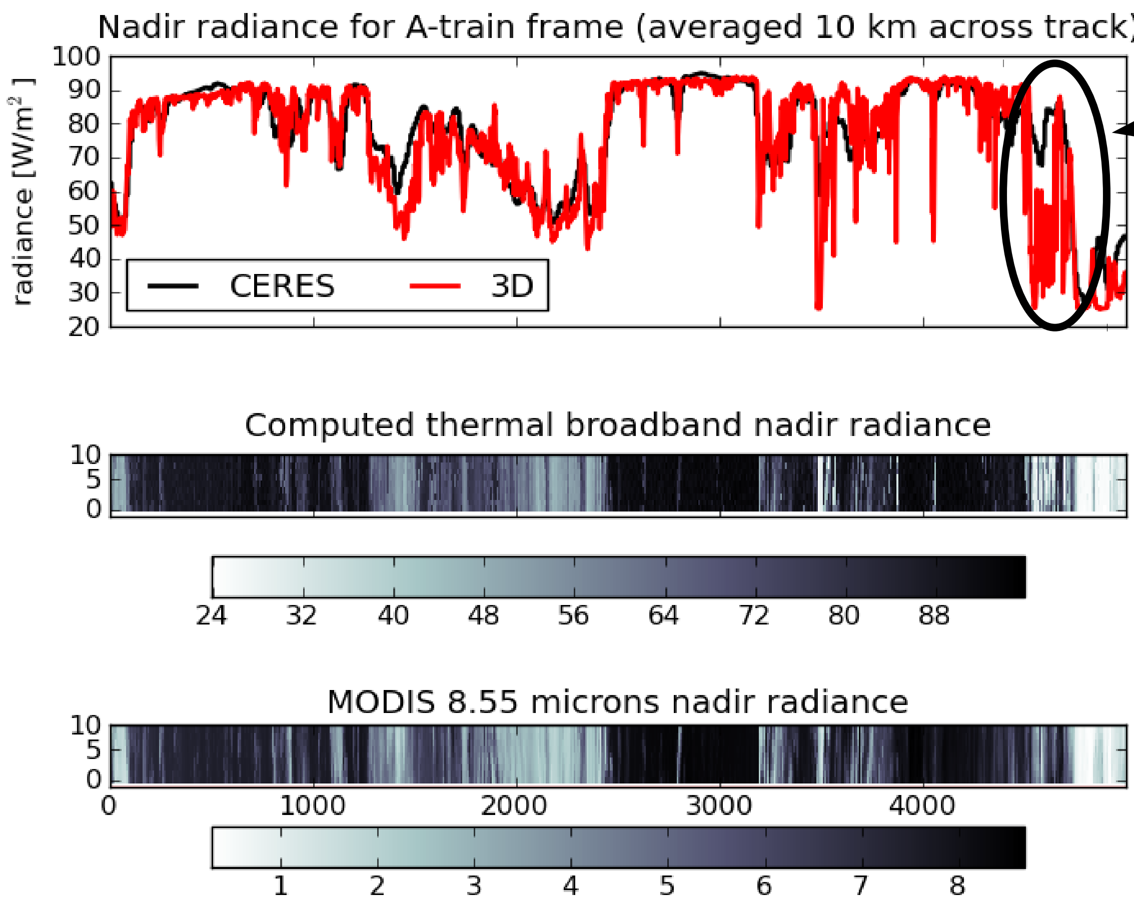
- Barker Monte Carlo code using RRTMG optical properties and solar source
- Mie liquid cloud and Yang ice cloud properties
- Radiances, fluxes and heating rates
- Variance reduction techniques
    - phase function truncation significantly speeds up radiance calculations
    - reduces required number of photons from 10 up to 10000 times





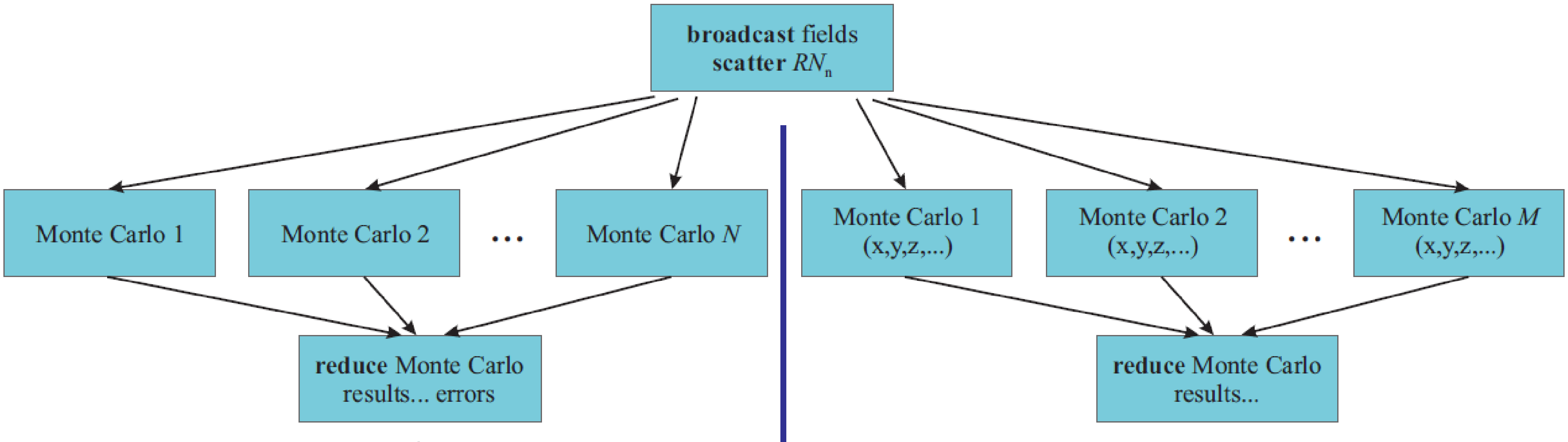
SRC - Radiative Transfer (3D Thermal)

- Cole Monte Carlo code using RRTMG optical properties and Planck functions
- Mie liquid cloud and Yang ice cloud properties
- Radiances only using backward Monte Carlo
- Backward tracing requires tracing back for each view and pixel
- Speed up by calculations using gray scattering for each band



Potential issue with ice cloud?

SRC - Radiative Transfer (Parallelization)



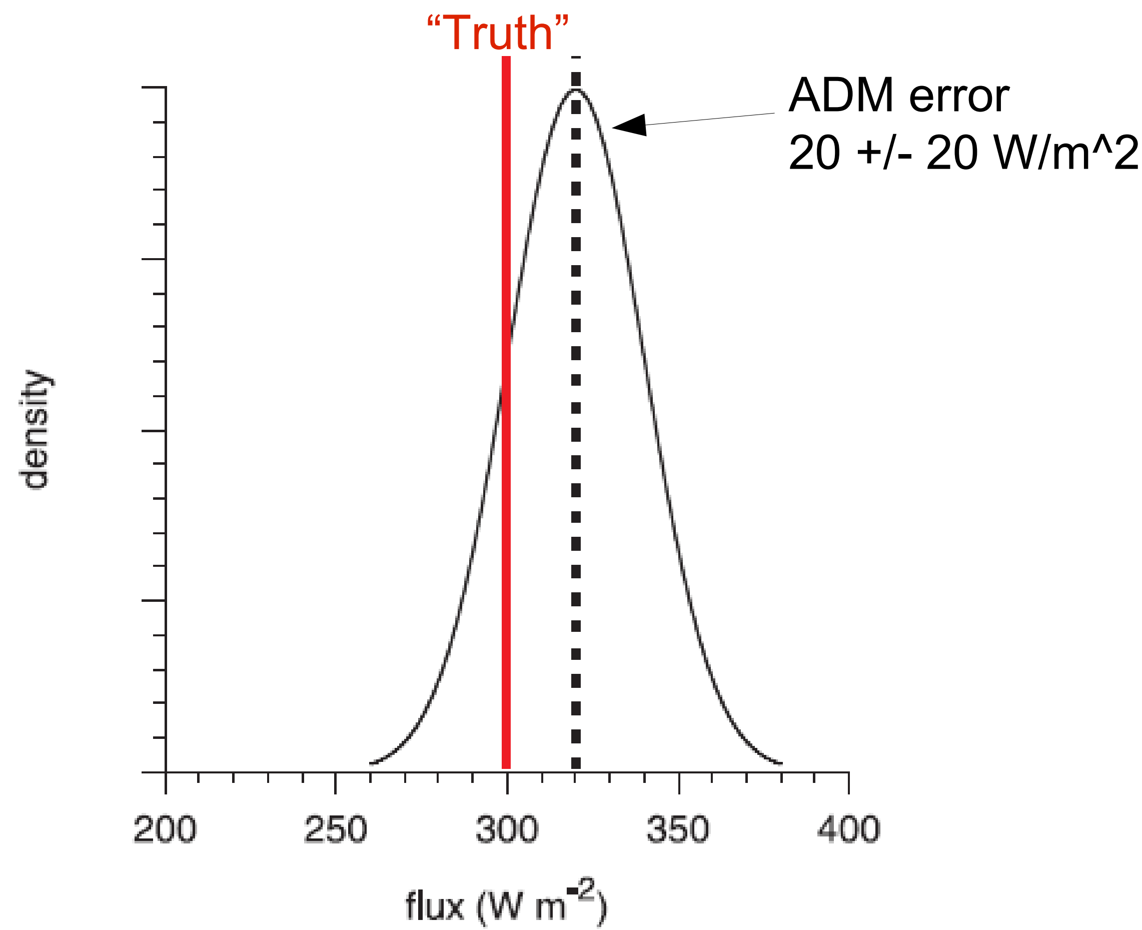
Compute Monte Carlo noise and determine convergence (N~30)

Estimate Monte Carlo uncertainty due to input uncertainties (M~300)

- Computing system to be determined
- Small cluster or potentially many processors on supercomputer
- Will determine efficiency of parallelization works and error estimate
- Determines resolution of radiances (1 km or something less)

SRC - Closure Assessment (under discussion)

- An idea is to use apply the same ADM to the observed and computed radiances.
- Makes the assessment more straightforward since three radiances reduced to a single value.
- Since we are only interested in the differences, weak dependence on ADM



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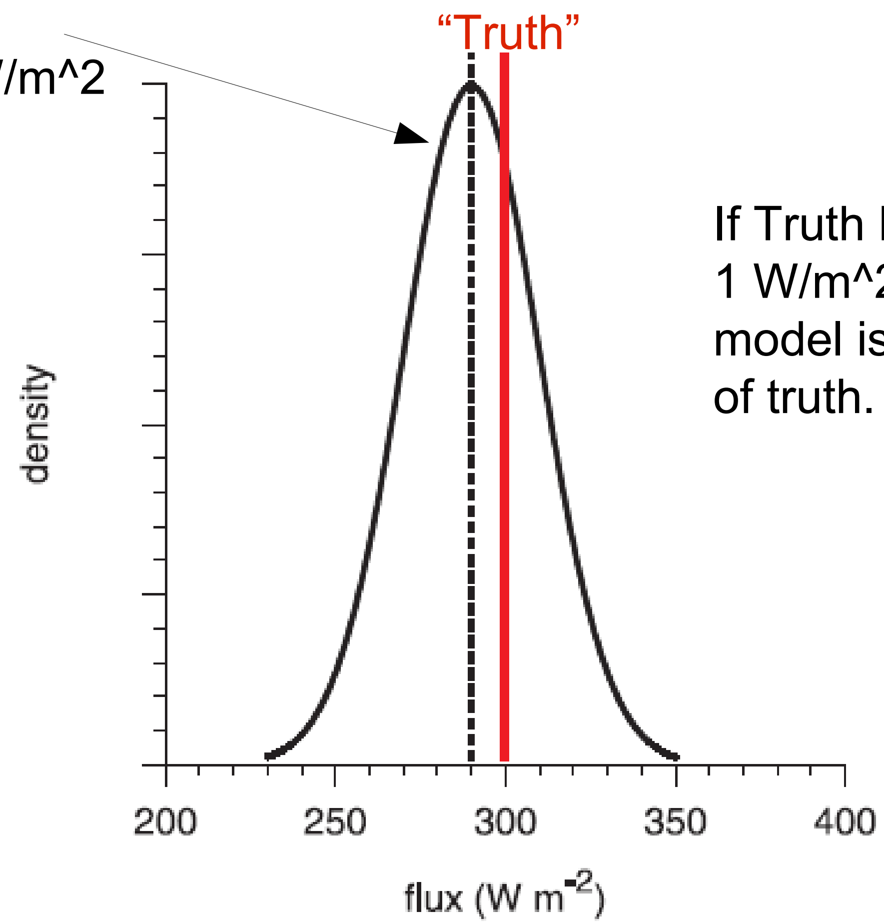
Model error
-10 +/- 20 W/m^2



If Truth has uncertainty of 1 W/m^2, 34% probability model is within 10 W/m^2 of truth.

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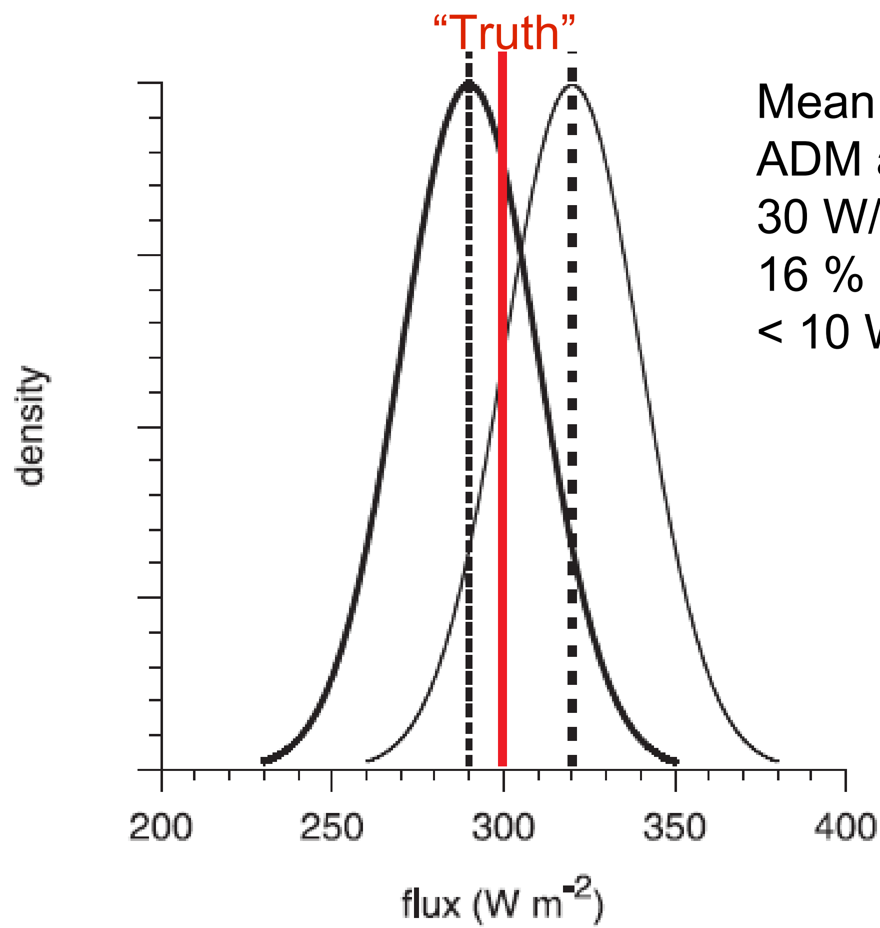

Mean difference between ADM and model fluxes is 30 W/m^2 but there is a 16 % probability they are < 10 W/m^2.

Summary

- Development of SRC algorithms for EarthCARE are well underway

- Utilizes 1D and 3D radiation transfer models
  - We believe a first use of operational 3D models
  - 3D codes are reasonably efficient and parallelized
  - May use parallelization to get a brute force estimate of input and retrieval uncertainty on 3D radiative transfer

- Use 1D and 3D to indicate where 3D is important

- In preparation for EarthCARE, SRC algorithms can, and should, be tested on A-train data data

- Plan to test using large CSRM output
  - We fully know the “answer”, test SCA and RT

- Integrate standalone code into ECSIM